NCRFC Routings

A Publication of the
NWS North Central River Forecast Center   Chanhassen, MN

In This Issue

Contact Us

NCRFC
1733 Lake Drive West
Chanhassen, MN 55317

Phone: (952) 361-6650
   FAX: (952) 361-6668

Routings Staff

Hydrologist in Charge
~ *Dan Luna*

Editor
~ *Robert Wavrin*

Multi-Agency Hydro Conference

On September 17, 18 and 19, 2002 a Hydro Conference was held at the North Central River Forecast Center in Chanhassen, MN. Participants from the following agencies/offices were in attendance:

☆ USGS Water Resources Office of Information - Reston, VA (Technical Operations Program Chief)

☆ USGS North Dakota District - Bismarck, ND (District Chief, Senior Staffers and Grand Forks Field Office Staffers)

☆ USGS Minnesota District - Mounds View, MN (District Chief, Senior Staffers and Grand Rapids Field Office Staffers)

☆ Manitoba Conservation/Water Branch - Winnipeg, MB (Senior Forecaster and Staffers)

☆ NWS MPX - Chanhassen, MN (MIC and SH)

☆ NWS FGF - Grand Forks, ND (MIC)

☆ NWS NCRFC - Chanhassen, MN   (HIC, Senior Staffers and Forecasters)

The Conference agenda included presentations and discussions about topics of mutual interest including the current USGS Data network (NSIP), Advanced Hydrologic Prediction Service (AHPS), general data sharing, an overview of the NCRFC operations, the Sacramento Soil Moisture Accounting (SAC-SMA) Rainfall Runoff Model, hydraulic routing, and the formation of an interagency coordination and communication program. A list of several items for future action and /or investigation were formulated by the group. Attendees were also given office/building tours of the WFO-Chanhassen, the North Central River Forecast Center and the National Operational Hydrologic Remote Sensing Center - NOHRSC.

NWS Blood Drive

In January 2000, a family member of an NWS Chanhassen forecaster was diagnosed with a very rare blood disease, Thrombotic Thrombocytopenic Purpura or TTP. The only known treatment for this disease is Plasmapheresis, or plasma exchange to remove unwanted substances from the blood. Over the course of 13 days, this individual received 260 units of plasma and six units of whole blood. (To equate this. . . If a person donated blood five to six times a year, or about every 56 days, it would take this donor about 43 years to donate the same amount of plasma and blood used by this patient in the 13 days.)   Fellow NWS Chanhassen staff members wanting to help and realizing the importance of routine blood donations, organized their first NWS blood drive.

American Red Cross

Together, we can save a life

In October, the NWS Facility, located in Chanhassen, Minnesota held its 2002 Fall Blood Drive in cooperation with the American Red Cross. This was the 6th Blood Drive held in the past two years. The Facility comprises approximately 65 staff members from three separate offices, the North Central River Forecast Center , the Twin Cities Forecast Office and the National Operational Hydrologic Remote Sensing Center. During each of the previous blood drives, 20 staff members, or about 30% of all three offices, have donated.

Ironically, the blood drive last Fall was held on September 11, 2001. A future blood drive at Chanhassen has already been scheduled for February 2003. Planning is currently underway to possibly include some of the other businesses in the area to be a part of these future NWS Blood Drives.

HIC Insights

Our Spring Snowmelt Season was quite benign with the exception of the Upper Peninsula of Michigan and northern Wisconsin. Extremely warm temperatures, coupled with record snowfall, and significant rains led to record flooding on the Menominee River, major flooding on several Upper Peninsula Rivers and several potential dambreaks! The NCRFC staff rose to the challenge and forecasts and lead times were excellent! We provided quality service to our customers and the staff is to be congratulated. Our Spring Snowmelt Flood Outlook for 2002, showed areas of moderate flooding over the Upper Peninsula of Michigan and minor flooding along the Mississippi.

Spring showers and thunderstorms led to near record flooding on the Illinois River in May. The Illinois was above flood stage from March 11-26, 2002 and from April 12-June 29, 2002 for a total of 95 days. Very heavy rains associated with thunderstorms in early June over eastern Iowa and Northern Illinois led to record flooding on the Rock River in Illinois and the Maquoketa River in Iowa.

We had several meetings this past spring and summer with cooperators and other local/state government officials concerning future forecast service. We continue to push ahead our pilot project with the USGS districts. The goal of this project is to share information more efficiently and with better intelligence, therefore the water agencies will be on the same page during flooding episodes.

We will turn our efforts to improving our model performance in these areas, ensuring the very best forecasts. We will forge ahead with the AHPS program, by providing AHPS in the Souris River Basin in North Dakota. Probabilistic forecasts will be issued for the entire NCRFC area by the end of FY05. Check our web page for schedules and maps. We continue to educate our users by holding seminars and visiting offices. We are exploring other options for the AHPS product suite and hope to have some experimental products on line this summer. We added additional forecast service at on the Cedar River at Austin, MN and Turtle Creek, MN. We will be implementing service at Como on the Rock River in Illinois and Cedar Falls on the Cedar River this year.

Please let us know if we can provide additional service and or products. We are here to serve our customers and we enjoy hearing from our partners and cooperators.

Calibration of an Empirical Unsteady Flow Routing Model: Can FLDWAV Improve River Forecasting in the Wapsipinicon River Basin, Iowa? A Joint Research Effort of the North Central River Forecast Center and Davenport WFO

This paper discusses the challenges of forecasting flood hydrographs on the Wapsipinicon River in Iowa (Figure 1) and explores a new forecasting model. Hydrologists have used lumped parameter flow routing methods to forecast flood hydrographs for many years, with varying levels of success. The objective of this study is to produce a more accurate river flood forecast by developing and testing a state of the art one-dimensional unsteady flow routing model for the Wapsipinicon River reach between Anamosa, Iowa and its confluence with the Mississippi River near Camanche, Iowa.

Figure 1. Location of the Wapsipinicon River Basin

The reach from Anamosa, Iowa to the Mississippi River, the lowest third of the watershed, was chosen to be the focus of this study. Significant hydrogeological changes occur from upstream to downstream on this sub-watershed, making lumped parameter models difficult to calibrate over the flow spectrum. For example, the lumped parameter model may calibrate well for peaks, but may not simulate the rising and falling limbs very well. A lumped parameter routing model translates hydrograph ordinates from point to point, from upstream to downstream along a river. These methods do not explicitly account for the geography of the river channel and floodplain. The FLDWAV routing model, with geography explicitly accounted for, has the potential to improve the forecast simulation and improve upon total forecast streamflow hydrographs.

The models

Hydrologic models of a watershed are driven with inputs of precipitation and temperature to predict runoff. Once calibrated, these models can be used to predict a watershed's response to any precipitation event (Bedient et al., 2000).

The Sacramento Soil Accounting Model (SAC-SMA) is a conceptual runoff model that represents an attempt to parameterize the soil moisture characteristics that affect streamflow production. This is done in a

manner that logically distributes applied moisture in various depths and energy states in the soil, would have rational percolation characteristics that are based on physiography, allowing an effective simulation of streamflow (Burnash, Ferral, 1996). It uses physical concepts to simulate water movement through the soil and accounts for changes in the soil moisture over time. The system requires the interpretation, in a reasonable manner, of the primary mechanisms that include precipitation, evapotranspiration, and soil moisture.

The FLDWAV model is a hydraulic streamflow routing model used for post flood analysis and real time forecasting of natural and dam-break floods. FLDWAV is an unsteady flow routing model, incorporating the features of two earlier National Weather Service (NWS) models; the Dynamic Wave Operational (DWOPER) model and the Dam Break (DAMBRK) model.

a) DWOPER, developed in the 1970's, is generalized for wide applicability to rivers'varying physical features, such as irregular geometry, variable roughness parameters, lateral inflows, etc. (National Oceanic and Atmospheric Administration, 1989).

b) DAMBRK, developed in the late 1970's, is a generalized model that can be used for real-time flood forecasting of dam-break floods, natural floods, and dam-breach flood analysis for sunny-day piping. The DAMBRK model computes the outflow hydrograph from a dam for spillway, overtopping, or dam-breach outflows (National Oceanic and Atmospheric Administration, 1989).

The hydraulic modeling features of FLDWAV effectively simulate water surface elevations at discrete locations along a river reach (Braatz et al., 1999). The flood wave is routed through the channel and flood plain using a four-point implicit finite difference numerical solution of the complete Saint-Venant equations of one-dimensional unsteady flow (Buan et al., 2000; National Weather Service, 1999). Buan (1999) used FLDWAV to model the Red River of the North after the 1997 flooding. Comparing model simulation results with observed hydrographs from the 1997 flood demonstrated the improved predictive capabilities of an unsteady flow model such as FLDWAV.

Geographic Information Systems

The development of geographic information systems (GIS) has changed the way spatial data are accessed and analyzed, thus introducing the possibility of using physical watershed characteristic hydrologic modeling (Greene and Cruise, 1995). A GIS approach can remove subjectivity and excess effort because spatial calculations can be done using the GIS method (Cheng and Ojiri, 1999). The delineation of the watershed is a crucial part of the hydrologic modeling process. In order for the results to be accurate, the area that is being modeled must be accurately represented. In the past, the delineation of watershed was done manually using contour maps. This method was very time-consuming and very costly (Cheng and Ojiri, 1999).

Study Methods

For development of the study model, 3 existing local watershed runoff calculation zones (DEWI4, OXJI4, and WTLI4) (Figure 2) were subdivided into 12 zones (Figure 3).

Figure 2. The Original 3 Basins

Figure 3. The 12 New Sub-Basins

This provided for finer resolution flow inputs to the river model between Anamosa and the confluence with the Mississippi River. The smaller zones were defined with the Integrated Automated Basin Boundary System (IHABBS) software, developed by the National Weather Services National Operational Hydrologic Remote Sensing Center (NOHRSC).

Unit hydrographs for the new runoff basins were developed using the Unit Hydrograph (UH) software, which was also developed by the NOHRSC and is associated with IHABBS. Once the basin boundaries are defined with IHABBS, the UH software will generate a synthetic unit hydrograph for the area. The UH software has a variety of options to generate a synthetic unit hydrograph. The option that was chosen for this study is the Distributed Time Area (DTA) method. The DTA method establishes a relationship between the travel time and a portion of a basin that may contribute runoff during the travel time. In a time area method, the watershed is broken into

areas of equal travel time. The mean travel time of each sub-area curve is the summation of the individual areas. For the time area parameter estimation, the segment approach is essentially the time of concentration or longest travel time within the basin. The sum of all travel times represents the time of concentration (NWS Hydrologic Laboratory, NOHRSC). In the DTA method, a routing coefficient (R factor) value can be adjusted for land use and flow regime of the area. By adjusting the value of the R factor (0.70 is default value), it will increase or decrease the height of the peak and the duration of the flow. Based on the slope of the terrain for the study area, 0.57 was the value used to generate a synthetic unit hydrographs for the study model.

Building Cross Sections for the FLDWAV Model

a) The first step in defining cross-sections for the model was to gather the necessary United States Geological Survey (USGS) 7.5-minute quadrangle maps of the study area. After these were obtained, one-mile increments were measured and labeled accordingly, starting at Anamosa and working toward the Mississippi River. The USGS 7.5-minute quadrangle maps with measured, one-mile increments were used as a reference when creating the cross-sections of the river channel in Arc/View. Scale Master II, a special measuring tool designed for measuring maps, was used for this task. Scale Master II is a digital-plan measuring system; it can measure at a variety of scales.

b) The next step was to download 1:24,000 digital raster graphics (DRGs) and 30-meter digital elevation model (DEMs) to cover the study area. They are capable of being exported to Arc/View, and with the use of Avenue, Arc/View's programming language, a script called Spatial Grid Mosaic merged these themes together, making a smooth transition between the overlapping areas. This produced a new, single theme; one for the DRGs and one for the DEMs. The one requirement necessary to use this script is the extension Spatial Analyst, which needed to be active from the extension window.

c) The two themes are made active and the DRG theme is overlayed on the DEM theme. With the use of another Avenue script, Profiler, a chart profile of each cross-section can be made. When selecting the desired cross-section areas, a text file is created with elevation coordinates of the river channel. This can be viewed as a profile in Arc/View (Figure 4).
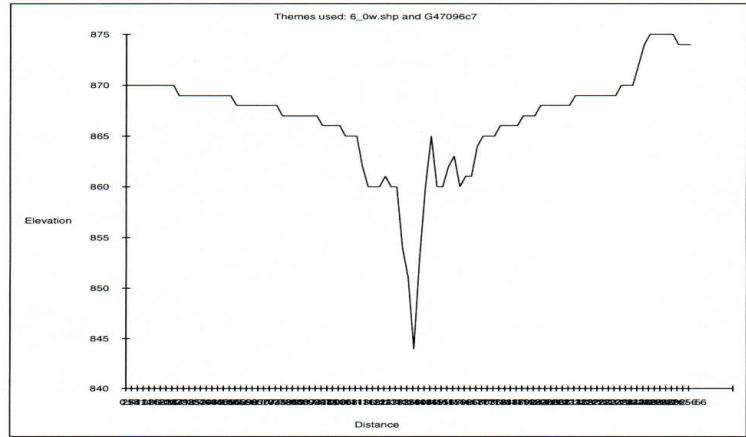
This script also required the use of the Arc/View extension, Spatial Analyst, and two active themes need to be selected: a line theme (DRG) and a grid theme of elevations (DEM).

d) The information produced from Arc/View is then transferred to a FLDWAV tools program where it will create a profile of each cross-section for view. With the FLDWAV tools, the channel width is measured in eight locations starting from the bottom of the channel. The next six sections are based on the largest change in the channel and the final location is based on historical records of flow levels. For example, if the highest recorded river level at a certain point were 16.5 feet, the final cross-section would be around 17.5 feet to provide for higher floods. FLDWAV will take the eight measured cross-sections and create a new profile. This profile will be uniform, with the sides of the channel nearly smooth. The final profile and the data obtained from this cross-section will be inserted as a parameter in the model.

Acquiring Field Data to Calibrate the FLDWAV Model

To calibrate the model, seven-crest gauge recorders and two staff gauges were installed to document events that occur in this reach (Figure 5, and Table 1). The USGS also has two wire weight river gauges and one automated river gauge that assisted in the gathering of data. Data was gathered over an 8-month period, which began in the middle of April, 2001 and lasted until the middle of December, 2001.
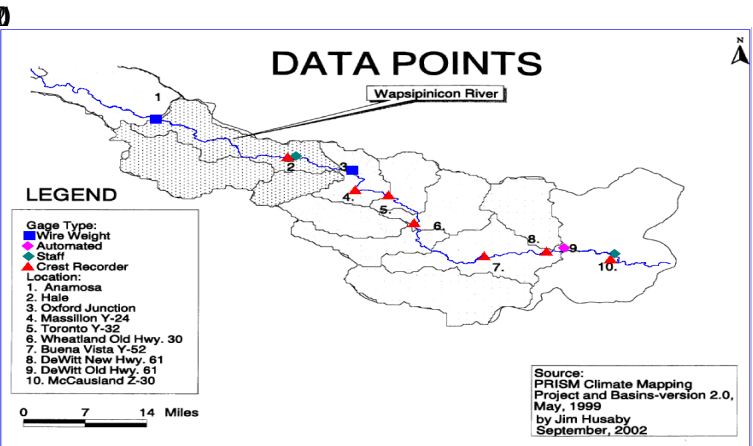

Figure 5. Data Point Types and Locations

Figure 4. Typical River Cross Section

Reference	Gage Style	Location
1	Wire Weight	Anamosa
2	Crest/Staff	Hale
3	Wire Weight	Oxford Junction
4	Crest Recorder	Toronto
5	Crest Recorder	Massilon
6	Crest Recorder	Wheatland
7	Crest Recorder	Buena Vista
8	Crest Recorder	De Witt-overflow
9	Automated	De Witt
10	Crest/Staff	McCausland

Table 1. Data Point Information

Summary

The primary mission of the National Oceanic and Atmospheric Administration's (NOAA's) NWS Hydrologic Services Program is to provide advanced, short-term river and flood forecast and warnings, for the protection of life and property (Larson et al., 1995; Larson and Graziano, 1997).

A FLDWAV routing model for the Wapsipinicon River was developed to assist in the accuracy of river flood forecasting. Preliminary results from calibration indicate an increase in accuracy of the timing of an event.

The Spring 2003 issue of NCRFC Routings will share the final results from the study. This will include the calibration of the model and will compare model simulation results with the observed results.

RIVER FORECAST VERIFICATION ON THE ILLINOIS RIVER

The establishment of long term verification statistics provides a measure of how well forecasting skills have improved over time. In our previous issue we shared an example of those forecasting skills at St. Louis MO. The NCRFC verification efforts include three locations on the Illinois River: La Salle, Peoria, and Beardstown IL. The two charts below show the average absolute daily forecast error by year for La Salle and Peoria. The statistics for Beardstown IL are almost identical to Peoria and have not been included. Again, the average absolute daily forecast error is defined as the the absolute value of the difference (measured in feet) between the forecasted stage for a given time and date and the actual observed stage on that date.

It is readily apparent that the average error is much larger at La Salle than at Peoria. The reasons for that show some of the challenges involved in preparing highly accurate forecasts. River levels at La Salle are affected by a number of factors. First, a portion of the urban runoff from the Chicago metropolitan area finds its way into the Chicago Ship Canal at Lockport IL and that water ultimately moves down the Illinois River. Secondly, there are a number of significant rivers and streams that flow into the Illinois River in reach above La Salle. This includes the Des Plaines, Du Page, Fox, Kankakee, Mazon, and Vermillion Rivers. Heavy rainfall over one or more of these rivers can cause relatively quick responses on the Illinois River. By the time the water moves downstream to Peoria the river response has been dampened and no additional rivers are introduced. Consequently the variability in the forecasts is considerably less.
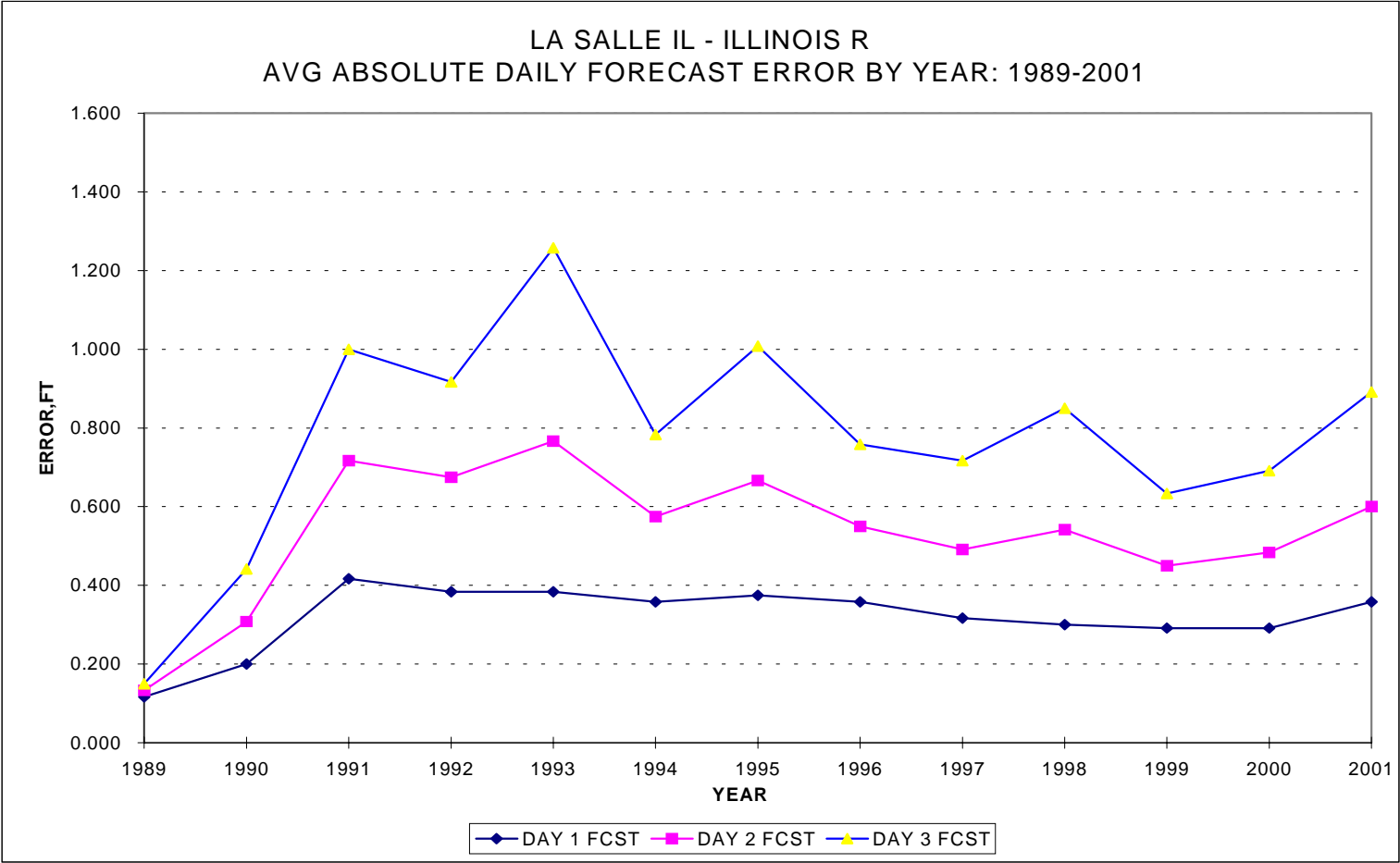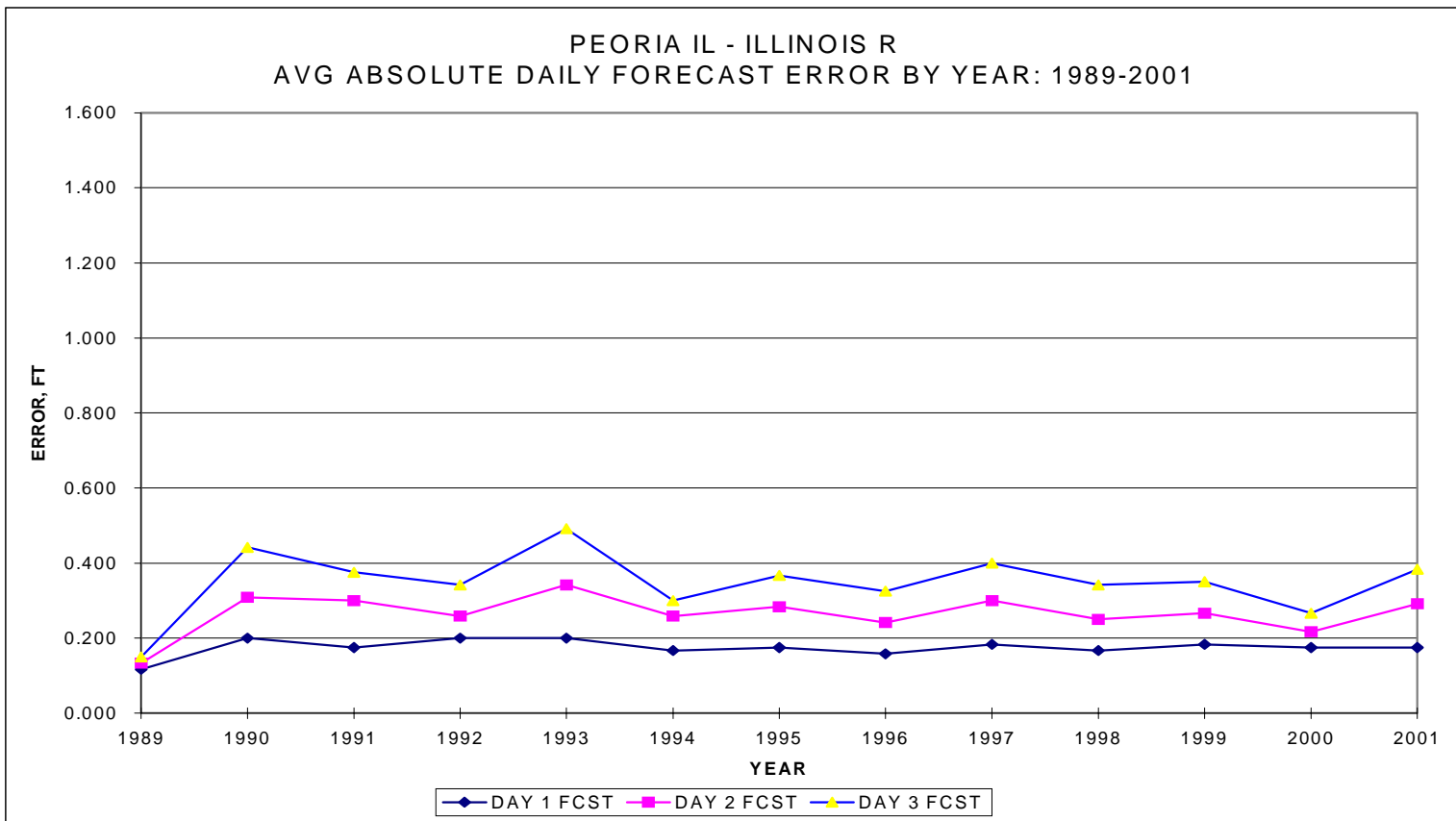

Figure 6. The Average Absolute Daily Forecast Error by Year (1989-2001) at La Salle IL

PEORIA IL - ILLINOIS R
AVG ABSOLUTE DAILY FORECAST ERROR BY YEAR: 1989-2001

Figure 7. The Absolute Daily Forecast Error by Year (1989-2001) at Peoria IL

National Weather Service
North Central River Forecast Center
1733 Lake Drive West
Chanhassen, MN 55317-8581

NCRFCs Web Address:
http://www.crh.noaa.gov/ncrfc/